THE INFLUENCE OF PHYSICAL CONDITIONS IN THE GENESIS OF SPECIES.

AMONG biologists who accept the modern theory of evolution as the only reasonable hypothesis available for the explanation of the diversity of structure among organized beings, there is a wide difference of opinion as to what are the leading causes of differentiation. The doctrine of natural selection, or the survival of the fittest, has recently been brought prominently forward as the key to this complex problem, and is upheld by a large class of enthusiastic adherents, who accept it as the full solution of the whole question. By others the conditions of environment are believed to be far more influential in effecting a certain class of modifications, at least, than the necessarily precarious influence of natural selection, which must take its origin in isolated instances of variation in favorable directions, and depend for its continuance upon these fortuitous advantages being inherited by the descendants of the favored individuals in which they originate. The modifying influence of conditions resulting from geographic or climatic causes, was long since noticed, and for nearly a century has been considered by many writers as explanatory of much of the diversity existing not only in the human race, but among animals. It has, however, remained, until recently, vaguely grounded, being based more in conjecture than on observed facts. Scarcely, indeed, have two decades passed since the real nature and extent of geographical variation among animals, and even as yet among only a few species, began to receive careful attention, while only within the last fifteen years has any attempt been made to correlate the observed differences with the climatic or geographical conditions of habitat. Only within recent years have the differences in

general size, and in the relative size of different parts, been ascertained by careful measurement, and the differences in the character of the tegumentary covering (as the pelage in mammals) and in color, in individuals of the same species inhabiting distant portions of a common habitat, been duly recorded. In the work of registering these instructive data, it has fallen to Americans to take a leading part; large credit in the matter being due not only to the activity of our professional biologists, but to the liberality of the general Government in attaching competent natural-history observers and collectors to the numerous surveying parties it has sent out during the last twenty years to explore the, till then, practically unknown geography and productions of our Western Territories. The combined fruits of their labors, together with those of the agents and correspondents of the Smithsonian Institution, have resulted in the accumulation of an amount of material far exceeding that elsewhere accessible to single investigators; representing, as it does, at least two of the vertebrate classes of animals from the whole North American continent so fully, that generalizations may be made from their study which could not otherwise have been reached for many years, and for which no similar facilities for any other equal area as yet exist. The recent investigations of American mammalogists and ornithologists have been, in consequence, largely directed to the subject of geographical variation; and their publications teem with tabulated measurements and records of variations in form and color that accompany differences in the climatic or geographical conditions of habitat. Among the results that have followed are the discovery of numerous interesting geographical varieties or sub-species, and the demonstration of the complete intergradation of many forms, often quite widely diverse in color, size, and proportion of parts, formerly regarded (and properly so as then known) as unquestionably distinct species; which discoveries have of course necessitated a large reduction in the number of recognized "specific" or non-intergrading forms. But most important of all has been the correlation of local variations with the conditions of environment, and the deduction therefrom of certain laws of geographical variation. Upon these have been based hypotheses that go far toward explaining many of the phenomena of intergradation

and differentiation observed among existing animals. In the present paper will be given not only a summary of the results thus far attained, but enough of the details of the subject to show the nature of the evidence on which rest the conclusions already reached. These results, it is claimed, show that other influences than natural selection operate powerfully in the differentiation of specific forms, and that geographical causes share more largely in the work than naturalists have heretofore been prepared to admit,—at least to consider as proven.

As is well known, animals vary greatly in respect to the extent of the areas they inhabit. While a few species are nearly or quite cosmopolitan, many others are restricted to single small islands, or to limited portions of a continent. Not a few range over the greater part of whole hemispheres, while by far the larger number are confined within comparatively narrow limits. Of the numerous species of mammals and birds inhabiting North America, none are equally common throughout the whole extent of the continent. The habitats of a few only extend from the Barren Grounds of the Arctic regions to Mexico, and from the Atlantic coast westward to the Pacific; one or two only among the mammals range over the whole continent from Alaska to Central America, while some occupy merely the extreme boreal parts of the continent. The latter, in many cases, range also over the Arctic and sub-Arctic regions of the Old World. Others extend from Arctic America southward to the United States. Still others occupy only the middle or more temperate latitudes, being unrepresented in the extreme north or the extreme south. Others, again, first appear in the middle or more southerly parts, and range thence southward far into the tropics. A large number are restricted to the region east of the Rocky Mountains; others are confined to a narrow belt along the Pacific coast; and others still to limited areas of the great Rocky Mountain Plateau. In general, their distribution accords with climatal regions or zones, their respective ranges being limited in part by latitude and in part by geographical barriers, as treeless, arid plains or high mountain ranges. The northern and southern boundaries of the habitat of a species are found to agree, not generally with the arbitrary parallels of the geographer, but with isothermal lines, these being more or less

different for each species. The geographical distribution of a species is thus mainly determined by climatic or other physical causes, though in part, doubtless, by its organic constitution. In most cases, species that are wide-ranging are the most variable, as would naturally follow from their being subjected, in the different portions of their habitats, to widely different environing circumstances. Hence such species are often found to run into numerous local races, some of them greatly differing from others, but still inseparably connected by individuals inhabiting the intervening regions. Over districts slightly diversified, even if of large extent, species generally preserve comparative constancy of character, while, conversely, local races are of frequent occurrence in regions of alternating valleys, mountain ranges, and table lands; and more especially is this true if the highly diversified region be situated in the warmer latitudes. Small islands, remotely situated from other lands, have usually many species peculiar to themselves, their differentiation being proportionate to the geologic antiquity of the islands and their remoteness from larger land areas. In islands of recent origin, and not widely separated from continental lands, the ancestral stock of the species is still often clearly apparent, the forms thus differentiated through insular influences not having passed beyond the varietal stage; in other cases they are specifically different from their nearest continental allies, or may even have advanced far toward generic distinctness, while their origin may still remain tolerably apparent.

Plasticity, or susceptibility to the influences of physical surroundings, often differs even among quite closely allied species, as those of the same family or even genus; and different species are evidently affected differently by the same circumstances. Variability in color may, or may not, accompany variability in size, or in the character of particular organs. Generally, however, a species which varies greatly in one feature, varies to a similar degree in many others. Species having a wide geographical range not only commonly run into a greater or less number of local races, but they generally present more than the average amount of strictly individual variation, as though species ranging widely in space were originally more plastic than those having more circumscribed habitats, and were thus able more easily to

adapt themselves to their surroundings; they are also more persistent, their fossil remains being far more frequently met with in the quaternary deposits than are those of the more local and generally more specialized forms.

Geographical variation, as exhibited by the mammals and birds of North America, may be summarized under the following heads: namely, (1) variation in general size, (2) in the size of peripheral parts, and (3) in color; the latter being subdivisible into (*a*) variation in color with latitude, and (*b*) with longitude. As a rule, the mammals and birds of North America increase in size from the south northward. This is true not only of the individual representatives of each species, but generally the largest species of each genus and family are northern. There are, however, some strongly marked exceptions, in which the increase in size is in the opposite direction, or southward. There is for this an obvious explanation, as will be presently shown; the increase being found to be almost invariably toward the region where the type or group to which the species belongs receives its greatest numerical development, and where the species attain the largest size, and are also most specialized. Hence the representatives of a given species increase in size toward its hypothetical centre of distribution, which is in most cases doubtless also its original centre of dispersal. Consequently there is frequently a double decadence in size within specific groups, and both in size and numerically in the case of species, when the centre of development of the group to which they belong is in the warm-temperate or tropical regions. This may be illustrated by reference to the distribution of the higher classes of vertebrates in North America. Among the species occurring north of Mexico, there are very few that may not be supposed to have had a northern origin; and the fact that some are circumpolar in their distribution, while most of the others (especially among the mammals) have congeneric Old World allies, further strengthens the theory of their northern origin. Not only do individuals of the same species increase in size toward the north, but the same is true of the species of the different genera. Again, in the exceptional cases of increase in size southward, the species belong to southern types, or, more correctly, to types having their centre of development within or near the intertropical regions, where occur

not only the greatest number of the specific representatives of the type, but also the largest.

For more detailed illustration we may take three families of the North American Carnivora; namely, the Canidæ (wolves and foxes), the Felidæ (lynxes and wild cats), and the Procyonidæ (raccoons). The first two are to some extent cosmopolitan, while the third is strictly American. The Canidæ have their largest specific representatives, the world over, in the temperate or colder latitudes. In North America the family is represented by six species,[1] the smallest of which (speaking generally) are southern, and the largest northern. Four of them are among the most widely-distributed of North American mammals, two (the gray wolf and the common fox) being circumpolar species; another (the arctic fox) is also circumpolar, but is confined to high latitudes. The three widest-ranging species (the gray wolf, the common fox, and the gray fox) are those which present the most marked variation in size. Taking the skull as the basis of comparison, it is found that the common wolf is fully one-fifth larger in the northern parts of British America and Alaska than it is in Northern Mexico, where it finds the southern limit of its habitat. Between the largest northern skull and the largest southern skull there is a difference of *about thirty-five per cent. of the mean size!* Specimens from the intermediate region show a gradual intergradation between these extremes, although many of the examples from the upper Missouri country are nearly as large as those from the extreme north.

The common fox, though occurring as far north as the wolf, is much more restricted in its southward range, especially along the Atlantic coast, and presents a correspondingly smaller amount of variation in size. The Alaskan animal, however, averages about one-tenth larger than the average size of specimens from New England. In the gray fox, whose habitat extends from Pennsylvania southward to Yucatan, the average length of the skull decreases from about five inches in Pennsylvania to considerably less than four in Central America,—a difference equal to about thirty per cent. of the mean size for the species.

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[1] The gray wolf (*Canis lupus*), the prairie wolf (*C. latrans*), the Arctic fox (*Vulpes lagopus*), the common fox (*V. alopex*), the kit fox (*V. velox*), and the gray fox (*Urocyon virginianus*).

The Felidæ, unlike the Canidæ, reach their greatest development, as respects both the number and the size of the species, in the intertropical regions. This family has but a single typical representative—the panther (*Felis concolor*)—north of Mexico, and this ranges only to about the northern boundary of the United States. The other North American representatives of the family are the lynxes, which, in some of their varieties, range from Alaska to Mexico. They form, however, the most northern, as well as the most specialized or "aberrant" type of the family. While they vary greatly in color, as well as in the length and texture of the pelage, at different localities, they afford a most remarkable exception to all laws of variation in size with locality; for a large series of skulls, representing localities as widely separated as Louisiana, Northern Mexico, and California on the one hand, and Alaska and the Mackenzie River District on the other, as well as various intermediate localities, reveals no appreciable difference in size throughout this wide area. The true cats, however, as the panther and the ocelots, are found to greatly increase in size southward, or toward the metropolis of the family. The panther ranges from the Northern States southward over most of South America. Skulls from the Adirondack region of New York have an average length of about seven and a half inches, the length increasing to eight and three-quarters in Louisiana and Texas, from beyond which points there is lack of data. The ocelot (*Felis pardalis*) finds its northern limit near the Rio Grande of Texas, and ranges thence southward far into South America. The average size of Costa Rican examples is about one-fifth greater than that of specimens from the Rio Grande.

The Procyonidæ are chiefly represented in tropical America, a single species—the common raccoon (*Procyon lotor*)—being found in the United States, and thence northward to Alaska. Here again the increase in size is southward, or toward the metropolis of the family,—Pennsylvania specimens averaging about one-tenth smaller than Costa Rican examples.

The common otter (*Lutra canadensis*) affords another example of increase in size southward among our Carnivora, although belonging to a family essentially northern in its distribution. The otters, however, form a distinct sub-family, which attains its

greatest number of species in the warmer regions of the earth; and hence offers, not an exception to, but a confirmation of, the law of increase toward the centre of distribution of the group to which it belongs.

Instances of increase in size northward among the Carnivora of North America are so generally the rule that further space need not be taken in recounting examples in detail. It may suffice to state that the badger (*Taxidea americana*), the marten (*Mustela americana*), the fisher (*M. pennanti*), the wolverine (*Gulo luscus*), and the ermine (*Putorius ermineus*),—all northern types,—afford examples of variation in size strictly parallel with that already noticed as occurring in the foxes and wolves.

To refer briefly to other groups, it may be stated that the Cervidæ (deer family) are mainly rather northern in their distribution; that the largest species occur in the colder zones, and that individuals of the same species increase rapidly in size toward the north. Some of the species, in fact, afford some of the most striking instances of northward increase in size; among which are the common Virginia deer and its several representatives in the interior of the continent and on the Pacific slope. It is also noteworthy that the most obviously distinctive characteristic of the group—the large, annually deciduous antlers—reaches its greatest development at the northward. Thus all the northern species, as the moose, the elk, and the caribou, have branching antlers of immense size, while the antlers are relatively much smaller in the species inhabiting the middle region of the continent, and are reduced to a rudimentary condition—a simple slender sharp spike, or a small and singly forked one—in the tropical species; the antlers declining in size much more rapidly than the general size of the animal. This is true in individuals of the same species as well as of the species collectively.

The Rodentia (the squirrels, marmots, spermophiles, mice, and their affines) offer the same illustrations in respect to the law of increase in size as the species already mentioned, the size sometimes increasing to the southward, but more generally to the northward, since the greater number of the species belong decidedly to northern types. There is no more striking instance known among mammals of variation in size with locality than that afforded by the flying squirrels, in which the northern race

is more than one-half larger than the southern; yet the two extremes are found to pass so gradually the one into the other, that it is hardly possible to define even a southern and a northern geographical race except on the almost wholly arbitrary ground of difference in size. The species, moreover, is one of the most widely distributed, ranging from the Arctic regions (the northern limit of forests) to Central America.

Among birds the local differences in size are almost as strongly marked as among mammals, and, in the main, follow the same general law. A decided increase in size southward, however, or toward the warmer latitudes, occurs more rarely than in mammals, although several well-marked instances are known. The increase is generally northward, and is often very strongly marked. The greatest difference between northern and southern races occurs, as in mammals, in the species whose breeding stations embrace a wide range of latitude. In species which breed from northern New England to Florida, the southern forms are not only smaller, but are also quite different in color and in other features. This is eminently the case in the common quail (*Ortyx virginianus*), the meadow lark (*Sturnella magna*), the purple grackle (*Quiscalus purpureus*), the red-winged blackbird (*Agelæus phœniceus*), the golden-winged woodpecker (*Colaptes auratus*), the towhee (*Pipilo erythrophthalmus*), the Carolina dove (*Zenædura carolinensis*), and in numerous other species; and is quite appreciable in the blue jay (*Cyanurus cristatus*), the crow (*Corvus americanus*), in most of the woodpeckers, in the titmice, numerous sparrows, and several thrushes and warblers, the variation often amounting to from ten to fifteen per cent. of the average size of the species.

As a general rule, certain parts of the organism vary more than does general size, there being a marked tendency to enlargement of peripheral parts under high temperature, or toward the tropics,—hence southward in North America. This is more readily seen in birds than in mammals, in consequence, mainly, of their peculiar type of structure. In mammals it is manifested occasionally in the size of the ears and feet, and in the horns of bovines, but especially and more generally in the pelage. At the northward, in individuals of the same species, the hairs are longer and softer, the under fur more abundant, and the ears

and the soles of the feet better clothed. This is not only true of individuals of the same species, but of northern species collectively as compared with their nearest southern allies. Southern individuals retain permanently, in many cases, the sparsely clothed ears and the naked soles that characterize northern individuals only in summer, as is notably the case among the different squirrels and spermophiles.

In mammals which have the external ear largely developed,—as the wolves, foxes, some of the deer, and especially the hares,—the larger size of this organ in southern as compared with northern individuals of the same species is often strikingly apparent. It is more especially marked, however, in species inhabiting extensive open plains and semi-desert regions. The little wood hare, or gray "rabbit" (*Lepus sylvaticus*), affords a case in point. This species is represented, in some of its varieties, across the whole breadth of the continent, and from the northern border of the United States southward to Central America, but in different regions by different geographical races or sub-species. In addition to certain differences of color and general size, the ears vary still more strongly. In the form inhabiting the Great Plains, commonly known as the little sage-brush hare (*L. sylvaticus, nuttalli*), the ears are considerably longer than in the eastern variety, and increase in size from the north southward, reaching their greatest development in Western Arizona and the desert region further westward and southward, where the variety of the plains proper passes into still another variety characterized mainly by the large size of its ears, which are in this race nearly twice the size they attain in the eastern variety. In the large long-eared "jackass" hares of the Plains, the ear likewise increases in size to the southward. In *Lepus callotis*, for example, which ranges from Wyoming southward far into Mexico, the ear is about one-fourth to one-third larger in the southern examples than in the northern. The little brown hare of the Pacific coast (*L. trowbridgei*) presents a similar increase in the size of the ear southward, as does, to a less extent, the prairie hare (*L. campestris*). Not only are all of the long-eared species of American hares confined to the open plains of the arid interior of the continent, but over this same region is the tendency to an enlargement of the ear southward stronger

than elsewhere. It is also of interest in this connection that the largest-eared hares of the Old World occur over similar open, half-desert regions, as do also the largest-eared foxes. On our western plains, the deer are represented by a large-eared species. Among the domestic races of cattle, those of the warm temperate and intertropical regions have much larger and longer horns than those of northern countries; as is shown by a comparison of the Texan, Mexican, and South American breeds, with the northern stock, or those of the south of Europe with the more northern races. In the wild species of the Old World, the southern or sub-tropical are remarkable for the large size of their horns. The horns of the American pronghorn (*Antilocapra americana*) are also much larger at southern than at northern localities.[1] Naturalists have also recorded the existence of larger feet in many of the smaller North American mammalia at the southward than at the northward, among individuals of the same species, especially among the wild mice, in some of the squirrels, the opossum and raccoon, as well as in other species.

In birds, the enlargement of peripheral parts, especially of the bill, claws, and tail, is far more obvious and more general than in mammals. The bill is particularly susceptible to variation in this regard,—in many instances being very much larger, among individuals of unquestionably the same species, at the southward than at the northward. This accords with the general fact that all the ornithic types in which the bill is remarkably enlarged occur in the intertropical regions. The southward enlargement of the bill within specific groups may be illustrated by reference to almost any group of North American birds, or to those of any portion of the continent. As in other features of geographical variation, the greatest differences in the size of the bill are met with among species having the widest distribution in latitude. Among the species inhabiting eastern North America we find several striking examples of this enlargement among the sparrows, black-birds, thrushes, crows, wrens, and warblers; in the quail, the meadow lark, the golden-winged woodpecker, etc. Generally the bill, in the slender-billed forms, becomes longer,

[1] The deer tribe, in which the antlers increase in size toward the north, offer an apparent exception to the rule of increase in size of peripheral parts toward the tropics. The antlers of the deer, however, are merely seasonal appendages, being annually cast and renewed, and are thus entirely different physiologically from the horns of bovines, which retain a high degree of vitality throughout the life of the animal.

more attenuated, and more decurved (in individuals specifically the same) in passing from the New England States southward to Florida, while in those which have a short, thick, conical bill there is a general increase in its size so that the southern representatives of a species, as a rule, have thicker and longer bills than their northern relatives, though the birds themselves are smaller. There is thus not only generally a relative, but often an absolute, increase in the size of the bill in the southern races. The species of the Pacific coast and of the interior afford similar illustrations, in some cases more marked even than in any of the eastern species. More rarely, but still quite frequently, is there a similar increase in the size of the feet and claws.

The tail, also, affords an equally striking example of the enlargement of peripheral parts southward. Referring again to the birds of the Atlantic coast, many of the above-named species have the tail absolutely longer at southern localities than at northern, and quite often relatively longer. Thus while the general size decreases, the length of the tail is wholly maintained, or decreases less than the general size; but, in some cases, while the general size is one tenth or more smaller at the south, the tail is ten to fifteen per cent. longer than in the larger northern birds. Some western species are even more remarkable in this respect; and in consequence mainly of this fact the southern types have been varietally separated from the shorter-tailed northern forms of the same species.

Variations in color with locality are still more obvious, particularly among birds, in which the colors are more positive, the contrasts of tint greater, and the markings consequently better defined than is usually the case in mammals. The soft, finely-divided covering of the latter is poorly fitted for the display of the delicate pencilings and the lustrous, prismatic hues that so often characterize birds. Mammals, however, present many striking instances of geographical variation in color.

As already stated, geographical variation in color may be conveniently considered under two heads. While the variation with latitude consists mainly in a nearly uniform increase in one direction, the variation observed in passing from the Atlantic coast westward is more complex. In either case, however,

the variation results primarily from nearly the same causes, which are obviously climatic, and depend mainly upon the relative humidity, or the hygrometric conditions of the different climatal areas of the continent. In respect to the first, or latitudinal variation, the tendency is always toward an increase in intensity of coloration southward. Not only do the primary colors become deepened in this direction, but dusky and blackish tints become stronger or more intense, iridescent hues become more lustrous, and dark markings, as spots and streaks or transverse bars, acquire greater area. Conversely, white or light markings become more restricted. In passing westward a general and gradual blanching of the colors is met with on leaving the wooded regions east of the Mississippi, the loss of color increasing with the increasing aridity of the climate and the absence of forests, the greatest pallor occurring over the almost rainless and semi-desert regions of the Great Basin and Colorado Desert. On the Pacific slope, north of California, the color again increases, with a tendency to heavy, sombre tints over the rainy, heavily-wooded region of the north-west coast.

Geographical variation in color among mammals, for reasons already stated, is generally, but not always, manifested merely through the varying intensity or depth of the tints. It is, however, often strongly marked. The common chickaree, or red squirrel (*Sciurus hudsonius*), for example, which ranges from high northern latitudes southward over the northern portion of the United States, shows an increase in the color over the middle of the dorsal surface from pale yellowish or fulvous to rufous. The fox squirrel of the Mississippi Valley (*Sciurus niger, ludovicianus*), which ranges from Dakota southward to the Gulf of Mexico, has the lower parts, at the northward, very pale yellowish-white, which tint gradually increases in intensity southward, till in Louisiana it becomes deep reddish-orange, the dorsal surface also becoming at the same time somewhat darker. Excepting the fox squirrels, and a Pacific coast variety of the chickaree, all the squirrels living north of Mexico have the lower parts white, while those inhabiting tropical America have the lower parts fulvous, deep golden, orange, or even dark brownish-red; specimens with the belly white being exceptional, though occasionally occurring in several of the species.

Mammals tend strongly to run into melanitic phases, which are especially developed at particular localities or over limited regions, but whether or not the result of geographical influences is not clearly evident. The whitening of the pelage in winter at the north in a considerable number of species of mammals, and in one genus of birds, and not elsewhere, is, on the contrary, a strictly geographical phenomenon, but seems to be the result of other than the ordinary causes of geographical variation in color. Its occurrence in some species, and its absence in others closely allied to them, is a fact not readily explained. It shows, however, how differently different animals are effected by the same influences. The change to a white winter livery is more complete in the higher latitudes, where the whiteness pervades the pelage to a greater depth, and continues for a longer period, the change being only partial in the southern representatives of species that exhibit this seasonal change of color.

In respect to southward increase in color among birds, a few examples only, out of the many almost equally striking, can be here given. These will be chosen from widely different groups, and will represent localities remotely separated, as well as very diverse styles of coloration. In comparing, for instance, New England examples of the common quail with others from southern Florida, the colors are found to be so much stronger and darker in the southern birds as to give the appearance of their being entirely distinct species; particularly when the smaller size and larger bills of the southern race are also considered. While in the northern birds the color of the dorsal surface is gray and rufous, slightly varied with black, the gray is wholly wanting in the southern type, the rufous is much stronger, and the black markings are very much broader. The lower surface is varied by transverse bars of black and white, but while in the northern birds the white bars are twice, or more than twice, the width of the black ones, in the southern birds they are often of equal width; or the black bars may be the broader, with much more black bordering the white throat-patch, giving, on the whole, a very much darker aspect to this region of the body. Yet, when a series is brought together from many intermediate localities, there is found to be a complete intergradation between the most extreme phases. In the common towhee the style of coloration

is entirely different from that seen in the quail, the colors being chiefly massed in large areas, with white markings on the wings, and large white spots at the ends of the outer tail-feathers. In this species, southern specimens differ from northern ones in the black of the upper parts and the chestnut of the sides being more intense, while the white markings on the wings and tail are greatly reduced in area. In the northern bird four of the outer pairs of tail-feathers have a large white spot near the end, while in the southern form only three pairs are thus marked.

In the purple grackle the plumage (in the males) is everywhere black, with, at the north, greenish or bronzy reflections; in the southern or Floridan form the black is more intense, and the reflections are steel-blue and purple, with iridescent bars across the middle and lower parts of the back. In the northern form the female is dull brownish-black, with little or no iridescence, while in the southern form the female is nearly as lustrous as the northern male. The two types differ so widely, not only in color, but, as previously noticed, in size and in the form of the bill, that, without the connecting specimens from intermediate localities, no ornithologist would hesitate to regard them as entirely distinct species; and they were, indeed, at one time so regarded. The red-winged black-bird has, excepting its red wing-patches, also a lustrous black plumage throughout, and presents a similar range of variation in general color with the preceding; while the red of the wing-patch becomes much darker at the southward, and its creamy-white border seen in the northern form changes to yellowish-orange in the southern.

The common blue jay, and the long-crested jays of the Rocky Mountain region, may be cited as illustrations of southward increase in brilliancy or intensity of coloring where the prevailing tint is blue; the green Mexican and Rio Grande jays of a passage from yellowish-green tints into bright yellow; the yellow-throated warblers (genus *Geothlypis*), several of the fly-catchers (genera *Myiarchus* and *Tyrannus*), and the meadow lark, as examples of increase in the area and intensity of yellow; several of the woodpeckers (genera *Centurus* and *Sphyrapicus*), the cardinal finches (genus *Cardinalis*), and some of the tanagers (genus *Pyranga*), of a similar increase of red; the goldfinches (genus *Chrysomtris*), and most of the species above-named, of

increase in extent and purity of black areas. The Rocky Mountain jays have, at the northward, a large portion of the plumage rather dark ashen, which further southward becomes bluish ash, and still further south culminates, in the Central American States, in blue. In the genus *Geothlypis*, the Maryland yellow-throat (*G. triches*), which ranges over the whole United States, and thence far southward, has at the northward the abdomen whitish; more to the southward, yellowish; and, in the West Indies, Mexico, and northern South America, runs into races in which the abdomen is bright yellow. At the same time the black markings about the head increase in extent and purity, and the general size becomes larger, the group having its metropolis in the tropical regions. In consequence of these variations in color and size, this species at the southward becomes differentiated into several more or less well-marked sub-species (formally accorded full specific rank), which are connected by an unbroken series of intergradations.

In the great-crested flycatcher (*Myiarchus crinitus*) of the United States, the yellow of the abdominal region is much the stronger in the southern birds: while the same is true of several of the western species of the same genus, which at the southward also pass into several recognizable sub-species.

The western goldfinch (*Chrysomtris psaltria*) affords a well-known instance of increase of black. This species is found in the western half of North America from about the parallel of 40° southward to Ecuador. The northern form has the black of the upper parts mainly restricted to the head, wing, and tail, the rest of the dorsal surface being olive-green. In northern Mexico the back begins to be more or less clouded with black, which tint increases in extent in Central America till it wholly replaces the olive-green, while in northern South America it becomes more intense and lustrous. In northern specimens the tail is marked with white spots, which either decrease greatly in size, or become wholly obsolete, in the southern races. The extremes, as may well be imagined, are widely diverse in their coloration, and, though formally regarded as entirely distinct species, have been found so thoroughly to intergrade that it is impossible to draw any lines of separation between the several races. Lawrences' flycatcher (*Myiarchus lawrencei*) affords also a striking example

of southward increase in the area and intensity of black. At the northward this species has a grayish-black crown, which gradually passes southward into a form with the crown wholly deep black. With the increase southward of the area and intensity of black markings, there is also in this, as in other species, a general increase in the intensity or depth of the other accompanying tints.

The red-bellied, or Carolina woodpecker (*Centurus carolinus*), a common bird of the United States, shows a strong increase of red on the head and lower surface of the body at the southward, in which this tint is not only much brighter, but also much more extended in the south-Florida birds than in those from the Northern States. At the same time it presents, in common with other species of the same family, a marked southward decrease in the size of the white transverse bars and spots of the dorsal plumage.

In the southern portion of the Mississippi Valley, the variation is in a tropical direction, and is merely due to the more northward extension there of tropical influences. In passing to the Plains and the Great Basin west of the Rocky Mountains, however, an entirely different phase of color variation is met with. Here, as a general rule, there is a loss of color, this region being characterized by the presence of subdued or faded tints in the representatives of species having a nearly continental range. The transition, however, is as gradual as is that of the climatic conditions, the paleness beginning near the eastern border of the great plains, and, increasing westward, reaching its extreme phase in the arid wastes of the almost wholly rainless districts of the far south-west,—South Nevada, Arizona, and the contiguous region westward and southward. In respect to this part of the subject, it is hardly necessary to say more than that the representatives of continental species found here are uniformly much paler than those inhabiting the adjoining regions; that in many cases the paler forms were originally described as distinct species, and are commonly recognized as varietally distinct, though found to inseparably intergrade with the neighboring darker forms. In addition to the general paleness, there is often an increase in the areas of white, and in some cases an accession of new ones.

The wooded, mountainous districts embraced in this region also give rise to peculiar local phases of color variation, to give a detailed account of which would too greatly extend the present paper. The tendency is mainly toward the development of more or less well-marked rufous or fulvous phases of coloration, with sometimes an accession of red, while not a few species have more than the usual amount of black. A most striking instance of increase of red at western localities is seen in the yellow-bellied woodpecker (*Sphyrapicus varius*), which, in some of its forms, ranges in the breeding season over the more northern and elevated wooded portions of the continent. In its eastern form the male has merely the chin, throat, and crown red, while in the female the red is restricted to the crown. In rare instances there is a trace also of a narrow red nuchal band. In the Rocky Mountain form, however, there is always a red nuchal band, the red on the throat is more extended in the male, and a small area of red appears also on the throat of the female. In the form met with in the Cascade Range the red begins to spread over contiguous portions of the plumage, while in the form occurring along the Pacific coast the red overspreads the whole head, neck, and breast, through which, however, the markings of the eastern birds can generally be readily traced. Here we have, at one end of the series, the red confined to a few distinct patches about the head, while at the other it extends over the whole anterior half of the body. Yet the intergradation between the two has been so fully traced that these diverse forms are now held, by competent authorities, as merely local races of a single species!

Another case of the increase of red over the same region is afforded by the golden-winged and red-shafted woodpeckers (genus *Colaptes*), in which yellow in the eastern form is replaced by red in the other; in the middle region of the continent the species being largely represented by individuals in which are variously combined the special characteristics of the two forms. In the present case the black cheek-patch of the eastern form is replaced by a red one in the western. Traces of the characteristics of the western type occasionally appear in the most eastern representatives of the eastern type, and, conversely, features of the eastern bird appear in the most western representatives of

the western, showing at least their close affinity and probable community of origin.

The Pacific coast region from California northward is characterized by a great accession of color, all the continental species being here represented by forms much darker even than on the Atlantic coast. Here the coloration is duller than at the southward, though perhaps equally strong, the general tendency being to fuscous or dusky tints. We consequently find among the mammals and birds of the United States three strongly marked phases of color-differentiation among representatives of the same species, characterizing the three most strongly marked climatal regions,—a bright, strongly-colored form east of the Great Plains, a pallid form over the dry central region, and a deeply-colored fuscous form over the rainy, heavily-wooded region of the north-west coast. Examples of this differentiation are afforded by apparently all the species whose habitats extend entirely across the continent, the several local forms being in some species only more strongly marked than in others. Among mammals illustrations are afforded by different species of squirrels, hares, mice, lynxes, deer, etc.; and among birds by six or eight species of sparrows, a number of woodpeckers, several flycatchers, thrushes, and warblers, the meadow lark, various hawks, owls, etc. Generally these several geographical forms were originally described as distinct species, and many of them are still thought worthy of recognition by varietal names. As intermediate links began to be discovered, they were at first looked upon as the result of hybridity between the supposed distinct species whose characters they respectively combined; but eventually such links were found to be too frequent, and too general over the areas where the habitats of the several forms come together, to render such a supposition longer tenable, it finally appearing evident that they were only the connecting forms between merely local races or incipient species.

The local races of any given region, as compared collectively with those of contiguous regions, and the manner of their mutual intergradation, point plainly to some general or widely acting cause of differentiation. This is indicated by the constancy of the results, so many species, belonging to numerous and widely distinct groups, being similarly affected. Will the

fortuitous, spontaneous results of natural selection yield a satisfactory explanation of these phenomena, or must we seek some more uniform and definitely acting cause? To briefly summarize the results above detailed, we have a somewhat uniform increase of size in some given direction affecting many species simultaneously and similarly over the same areas. We have a frequent enlargement of peripheral parts, affecting not a few but many species, and all in a similar manner, though in varying degrees. We have a very general increase in the depth or intensity of colors southward, a general loss of color in approaching the central, arid portions of the continent, and again an excessive increment of color under still different climatic conditions and over a different area. We find the increase of size among the individuals of any given species to be quite uniformly in the direction of the centre of distribution of the group to which the species belongs, this being especially well-marked in mammals. We find the increase in the size of peripheral parts,—as the external ear and the length of the pelage in mammals, and the size of the bill and length of the tail in birds,—to be in the direction of the regions where these parts meet respectively their greatest development,—the increase in color (especially among birds) toward the region where are developed the richest and most lustrous tints, the loss of color in the direction of the region where the greatest general pallor prevails. We find again that the enlargement of peripheral parts correlates with increase of temperature; the southward increase of color with an increase of atmospheric humidity and temperature, and consequently with the protective influences of luxuriant arboreal vegetation and clouds; and, conversely, the loss of color accompanying excessive aridity, a scanty vegetation, and an almost cloudless sky,—the conditions, in short, of all others the most powerfully effective in the blanching of color; and again the sombre, dusky tints of the north-west coast accompanying the most humid conditions of climate and the conditions generally most favorable for the protection or preservation of color. Are these merely accidental coincidences, or are they the evident results of cause and effect? Because the white winter livery of some of the northern species is more protective against cold than darker tints would be, or aids in concealing them in some cases (as in the hares and ptarmigans) from

their enemies, or in other cases (as in the ermines and the Arctic fox) tends to aid them in stealing unperceived upon their prey, are they to be regarded as unquestionably the beneficial results of the working of natural selection? Because the dull gray tints of species inhabiting the semi-desert regions of the interior harmonize well with the general gray aspect of their surroundings, is this concordance the result again of the operation of the law of natural selection, the less favorably colored having been weeded out in the struggle for existence? Are the heavy, dull colors of the humid region of the north-west the result, again, of the necessary influence of natural selection in perpetuating only the individuals whose colors best accord with their sombre conditions of environment? Has the same action brought about the bright, rich coloration of birds, insects, and other animals under the warm humid conditions of the hotter parts of the earth, preserving the ratio of brilliancy of coloration with that of the conditions that everywhere most favor such differentiation? Finally, is the exact correlation of the changes in coloration with the gradual change of climatic conditions in passing from one geographical region to another the result in like manner of the long-continued weeding out of the less-favored? Or are these modifications severally due to the *direct* action of the conditions of environment?

In answering these questions it may be well to glance first at the nature of the theoretical origin of differentiation through the influence of natural selection as expounded by the leading advocates of the theory. As is well known, all the individuals of a species found at the same locality (differences resulting from sex and age aside) are not all cast in the same mould, but differ constantly, the average range of purely individual variation in general size and in the size of different parts ranging (in birds and mammals) from eight to fifteen or twenty per cent. of the average size for the species, with a corresponding amount of variation in color. These variations are found to tend in every conceivable direction, and it of course follows that some of them must be in directions exceptionally favorable to the species. The theory of modification by the action of natural selection only supposes that the stronger or otherwise more favored individuals transmit their favorable qualities to their offspring,

and that the latter, in consequence of their inherited advantages, multiply more rapidly than their less favored relatives; that these favorable deviations from the parental stock become in subsequent generations more pronounced, and that the original form is eventually overpowered and supplanted by its modified descendants. From the same original stock may be conceived to arise, even simultaneously, other forms diverging in different, though still favorable, directions, these in turn giving rise to several lines of descent, occupying perhaps different portions of the habitat of the original species, where they also multiply and become dominant, and eventually pass on from the stage of incipient species to more or less widely differentiated types. These premises being admitted,—and they are certainly within the bounds of reasonable conception,—only the element of time, apparently, is requisite for the development of an endless variety of unstable forms, constantly increasing in number and following divergent lines of development, and thus capable, apparently, of giving rise to all the diversity of organisms at present peopling the earth.

But there are many adverse circumstances with which the favored forms have in the outset to contend, and to which, in the majority of instances, they must succumb. These are, first, the minuteness of the first favorable divergence, the isolation of the individuals in which it appears, and consequently the impossibility of such individuals pairing with others similarly favored, and the consequent tendency of the offspring to possess the favorable characters in a less rather than in a greater degree than the parent, and to be absorbed into the original stock. Secondly, in case the incipient advantages are perpetuated, as it is necessary to suppose, the new offshoot must originate from a single point, and spread thence gradually to contiguous regions as its representatives slowly multiply.

But it is supposed, again, that new forms are not always thus gradually evolved from minute beginnings, but sometimes—perhaps not unfrequently—arise by a *saltus;* that individuals may be born widely different from their parents, differing so widely and persistently as not to be so readily absorbed by the parental stock. In proof of this, instances are cited of new species apparently appearing suddenly, and of varieties thus originating under artificial conditions resulting from domestication.

Granting that new forms may thus arise, although as yet few facts have been adduced in its support, they are necessarily at first local, and in no way accord with the observed geographical differences that characterize particular regions, and which affect similarly many species belonging to widely different groups.

The direct influence of climatic or geographical conditions upon animals is, in the main, ignored by the leading exponents of the doctrine of natural selection. To quote Mr. Darwin's own words on this point:—

"The action of climate seems at first sight to be quite independent of the struggle for existence; but, in so far as climate chiefly acts in reducing food, it brings on the most severe struggle between the individuals, whether of the same or of distinct species, which subsist on the same kind of food. Even when climate, for instance extreme cold, acts directly, it will be the least vigorous, or those which have got the least food through the advancing winter, which will suffer most. When we travel from south to north, or from a damp region to a dry, we invariably see some species gradually getting rarer and rarer, and finally disappearing; and the change of climate being conspicuous, we are tempted to attribute the whole effect to its direct action. But this is a false view: we forget that each species, even where it most abounds, is constantly suffering enormous destruction at some period of its life from enemies, or from competitors for the same place and food; and, if these enemies or competitors be in the least degree favored by any slight change of climate, they will increase in numbers, and, as each area is already fully stocked with inhabitants, the other species will decrease. When we travel southward and see a species decreasing in numbers, we may feel sure that the cause lies quite as much in other species being favored, as in this one being hurt. So it is when we travel northward, but in a somewhat lesser degree, for the number of species of all kinds, and therefore of competitors, decreases northwards; hence, in going northward, or in ascending a mountain, we far oftener meet with stunted forms, due to the *directly* injurious action of climate, than we do in proceeding southward or in descending a mountain. When we reach the Arctic regions, or snow-capped summits, or absolute deserts, the struggle for life is almost exclusively with the elements. That climate acts in main part indirectly by favoring other species, we may clearly see in the prodigious number of plants in our gardens which can perfectly well endure our climate, but which never become naturalized, for they cannot compete with our native plants, nor resist destruction by our native animals."[1]

While there is perhaps little reason to question the general correctness of the above-quoted generalizations, they have little bearing upon the question of the modification of species by the direct action of climatic conditions, but relate mainly to such unfavorable climatic influences as tend toward the extinction of species, or to the circumscription of their ranges. Indeed, the

[1] "Origin of Species," 5th ed., pp. 80, 81.

phenomena of variation detailed in the foregoing pages were almost wholly unknown at the time the earlier editions of the "Origin of Species" were published, and have hardly as yet become the common property of naturalists. Gradual decrease in size southward in hundreds of species inhabiting the same continent, or a gradual increase or decrease in color in given directions on a similarly grand scale, are facts but recently made known, and have not as yet been very fully discussed by evolutionists of the purely Darwinian school. Mr. Darwin, indeed, in referring to the "effects of changed conditions" upon animals, alludes to facts of a similar character,—as the alleged brighter colors of European shells near their southern limit of distribution and when living in shallow water, and the more sombre tints of birds that live on islands or near the coast under overcast skies, as compared with those of the same species living more in the interior, etc.; but is in doubt as to how much should be attributed, even in such cases, "to the accumulative action of natural selection, and how much to the definite action of the conditions of life." "Thus," he says, "it is well known to furriers that animals of the same species have thicker and better fur the farther north they live; but who can tell how much of this difference may be due to the warmest-clad individuals having been favored and preserved during many generations, and how much to the action of the severe climate? for it would appear that climate has some direct action on the hair of our domestic quadrupeds." [1] Since, however, it happens that some species do not vary at all, although living under the most opposite climates, he is thereby inclined "not to lay much weight on the direct and definite action of the conditions of life," though he fully admits "that strong arguments of a general nature may be advanced on the other side." "In one sense," he adds, "the conditions of life may be said, not only to cause variability, but likewise to include natural selection; for the conditions determine whether this or that variety shall survive." [2] But he says again: "I believe that natural selection generally acts slowly in effecting changes, *at long intervals of time, and only on a few of the inhabitants of the same region.*" In a latter work, however, he

[1] "Origin of Species," pp. 166, 167.

[2] Ibid., p. 168.

refers to the variation in color with locality seen in many species of birds in the United States, and says explicitly, in reference to northern and southern localities, "this seems to be the direct result of the difference in temperature, light, etc., between the two regions." [1]

There is, however, a vast amount of unquestionable proof of the direct and constant action of climate and other conditions of life upon animals, and that such geographical variations as the thicker and softer fur of mammals inhabiting cold regions, smaller size and brighter colors at the southward, etc., etc., do not require the action of natural selection, in its strict and proper sense, for their explanation. It is well known, for instance, that a flock of fine-wooled sheep, when taken to a hot climate, rapidly acquire a coarser and coarser fleece, till, in a few generations, it nearly loses its character of proper wool, and becomes simply hair; that the change affects simultaneously the whole flock, and is not brought about by one or two individuals acquiring a coarser fleece and through their descendants modifying the character of the herd. Furthermore, in the case of sheep, it is well known that certain countries are very favorable to the production of a fine fleece, and that fine-wooled breeds, even by man's aid, cannot be perpetuated in other regions. Again, it is a fact of common observation that in birds and mammals colors become more or less faded toward the moulting season simply by the direct action of the elements,—the tints of the fresh and the long-worn plumage or pelage being more or less strikingly different in the same individuals,—and that this contrast at different seasons is more marked in arid than in moist regions, through the greater bleaching effect of a dry heated atmosphere and the more intense dazzling sunlight of regions that are not only cloudless, but lack the protection afforded by abundant vegetation.

While so much is claimed by the writer as due to the direct action of climatic causes, it is admitted also that habits and food, and other conditions of life than those resulting from climate, have a marked effect in determining modifications of form and color among animals. A scarcity of a favorite kind of food

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[1] "The Descent of Man," 2d ed., p. 225.

will undoubtedly force species to subsist upon the next best that offers, which may be so different as to modify certain characters and fit the species to live upon the less desired food. A change of food may lead to modification of dentition, the muscles of mastication, and the organs of digestion, and, correlatively, of other organs or parts of the body; the modification, however, arising simultaneously among all the descendants of the individuals thus driven to a change of diet, instead of appearing first in a single individual and becoming perpetuated in its descendants alone. Entomologists have found that, among insects of the same species, the forced or voluntary use of different food-plants gives rise to modifications of color and structure, and hence result in what have been termed phytophagic varieties or sub-species, and that man can also effect such changes at will by simply changing the food of the species. Again, the geological character of a country is well known to have a marked effect upon the size and color of animals inhabiting it, as is strikingly illustrated among molluscous animals, whose abundance, and even presence, is largely dependent upon the constituents of the soil. Over regions of the United States, for example, where the underlying rock is non-calcareous, the species are both few in number and sparsely represented, while in other regions, where limestone abounds, but which are in other respects essentially the same, the species are far more numerous and far more abundantly represented. In respect to the fresh-water mussels, those of the same species from different streams are easily distinguishable by differences in the thickness of the shell, in color, shape, and ornamentation, so that the character of the shells themselves affords a clew to the locality of their origin. At some localities the species tend to become tuberculous or spinous, this being particularly the case toward the southward; at other localities they acquire a very much thickened shell, or different colors, the same characteristics appearing simultaneously in quite diverse species, and thus becoming distinctive of particular localities. In regard to mammals, measurements of large series of the skulls of minks, martens, squirrels, and other native species, show that the representatives of these species living in northern New England and north-eastern New York are smaller than the representatives of the same species occurring in the limestone districts of

Pennsylvania and the States more to the westward, and the same is true of the different kinds of domestic cattle. This is in opposition to the law of decrease in size southward that elsewhere and generally characterizes these same species, and seems obviously related to the geological character of the country at these localities; small size, in opposition to a general law, occurring over northern non-calcareous districts, and larger size more to the southward where the underlying rock is limestone. In this case the difference obviously results from the direct action of the conditions of habitat upon every individual rather than from "slowly effected changes" originating in "only a few of the inhabitants" of these respective districts.

Use and disuse of organs, through changes of habit resulting from changed conditions of environment, must result in some modification of the organ involved. As an example may doubtless be cited the passerine birds of some of the smaller, remotely-situated islands, as the Guadelupe and Galapagos groups, where recent investigations have shown that most of the species differ similarly in several features from their nearest allies of the mainland, and of which they are unquestionably insular forms. These differences consist in the greater size of the bill, shorter wings, longer tails, and darker colors. The sedentary life necessitated by the confined habitats of species thus situated would naturally act more or less strongly on the organs of flight, and a reduction in the size of the wing would follow;—not necessarily through the round-about process of natural selection, through the modification originally of a single individual, but by the direct action on all the individuals alike of the changed conditions of life.

It is doubtless unnecessary to further multiply examples of the modification of animals by the direct action of the conditions of life. The subject is one that can be but imperfectly treated at best in a short paper like the present. The illustrations have here been drawn from a limited geographical field, and mainly from among the two higher classes of vertebrates. There are, however, abundant indications that other fields and other classes would yield results equally confirmatory of the direct action of physical conditions in the evolution of specific forms among animals and plants. Changes in environing conditions

will, however, go but a short way toward explaining the origin of the great diversity of structure among existing organisms; the character of the food, habit, or the increased use or the disuse of particular organs, may explain many of the modifications, leaving a large share of the work to as yet unknown causes. Natural selection, as sometimes defined, is made to cover all causes of differentiation, it being stated by Mr. Darwin himself that, if organic beings undergo modification through changes in their conditions of life, "uniformity of character can be given to their modified offspring solely by natural selection preserving similar favorable variations." In its strict sense, variation by natural selection results only through favorable differences appearing at first in single isolated individuals, which transmit these favorable qualities to their offspring, in virtue of which they multiply till they outnumber, crowd out, and finally destroy the less favored form from which they originated.

It is hardly conceivable, for example, how the peculiar structure seen in the woodpecker, the kingfisher, the swift, the heron, or the duck, or the peculiar dentition and correlated characters of the rodents, the ruminants, or the shrews and moles, as compared with the Carnivora, can have been initiated by the direct action of climatic conditions, however much other conditions of environment may have favored the development of these diverse types.

Having thus far mainly detailed merely facts and coincidences relating to the subject of variation with locality, it may be well in conclusion to consider more fully some of the possible or probable causes of purely geographical variation. In regard to geographical variation in color, it seems evident that high temperature, conjoined with moisture, favors increase of color and especially the acquisition of lustrous tints, while moisture alone favors simply increase in depth or the production of dull, heavy, and especially fuscous phases of coloration; on the other hand, that aridity and exposure favor the loss of color. The latter is due apparently no less to the influence of a dry and often intensely heated atmosphere than to the direct action of light intensified by the reflection of the sun's rays from almost verdureless sands. That the latter conditions act powerfully in blanching color there is most abundant proof. Hence we have

the necessary correlation of increase of bright rich tints of coloration with the increase of atmospheric humidity. In respect to the enlargement of peripheral parts at the southward, it is obvious that a high temperature favors the more rapid circulation of the blood in these parts, while, as is well known, a low temperature produces the opposite effect, and necessarily retards their development.

With the decrease in size among birds, there has been observed a decrease of vivacity and deterioration of song, which may reasonably be attributed to the enervating influence of a high temperature. Since the northern types of animals reach their highest physical development toward the northward, it seems fair to suppose that decrease in size southward may be directly due to the enfeebling influences of increase of temperature, since certainly it cannot be attributed, in the majority of cases at least, to greater scarcity of food, for, in many instances, just the reverse obtains. This supposition is in accordance with the known effects of similar climatic conditions upon the northern races of man, which reach their greatest vigor and highest intellectual status under temperate conditions of climate, and deteriorate, both physically and mentally, on removing to intertropical regions. Again, the mammals and birds of the United States reach their maximum size within the United States under the stimulating climate of the region drained by the Upper Mississippi and Upper Missouri Rivers, being, as a rule, larger here than in corresponding latitudes more to the eastward. The decrease in size toward both the northern and southern borders of the habitat of a given species or genus, of which there are many marked instances, further shows that size varies with the varying conditions of habitat, and reaches the maximum only where the conditions are most favorable to the life of the species.

Much has been written respecting the influence of climate on man, and many speculations have been indulged in in relation to the part the conditions of life have taken in bringing about the diversity at present existing among the different races. A striking parallelism is often observable between the leading features of geographical variation among animals and the physical differences that obtain among nations or races of men inhabiting

the same areas and subjected to the same influences. While civilized man is, in a measure, less the subject of such influences than the lower animals, he is not wholly above them. Certain regions more favor both physical and intellectual development than others; and these prove to be, as would be expected, the milder temperate portions of the globe, where the struggle for a mere vegetative existence is reduced to a minimum.

The influence of different climatic conditions upon members of the same nationality find exemplification in different parts of our own country, and are so obvious as to be the subject of frequent observation and comment. The same original stock is found to gradually develop certain peculiar physical and mental characteristics when placed under diverse conditions of climate, certain localities more favoring intellectual growth and activity than others; just as certain regions are characterized by the frequent occurrence of particular diseases, which in other regions are exceptional. While humidity and a high temperature, when combined, are found to be enervating and deteriorating, a clear dry atmosphere favors vigor of both mind and body. But the subject of the influence of climatic conditions upon man is too vast to be entered upon in detail in the present connection. The study of man from a geographical standpoint, or with special reference to conditions of environment, offers a most important and fruitful field of research, which, it is to be hoped, will soon receive a more careful attention than has as yet been given it.

In conclusion, a few words seem called for concerning the question, What is a species? as well as in respect to the bearing of the general facts above detailed upon the evolution of specific forms.

As is well known, the belief that species were distinct and immutable creations was long the prevailing one among naturalists. Yet the question of what constitutes a species is one about which endless discussions have arisen, and one respecting which the most discordant opinions have been held by naturalists equally eminent in their respective fields of research. The amount and kind of difference necessary to characterize a species has been variously defined; forms that some have considered as specific others have regarded as merely varieties, and the reverse. In

certain groups of organisms intermediate forms have been constantly met with, constituting steps of easy intergradation between quite diverse types. Such forms have been, and still are, held by some writers as varieties of a single species, and by others as constituting a group (genus or sub-genus) of distinct, but nearly related, species. Through the frequent discovery of such intergradations, however, the instability of so-called "species" has been made manifest, and the contrary doctrine of the stability or fixity of species refuted. Indeed, naturalists now generally agree that the terms variety, species, genus, sub-genus, family, sub-family, super-family, and the like, are but conventional and more or less arbitrary designations for different degrees of differentiation,—convenient formulæ for the expression of general facts in biology. Not a few high authorities even maintain that the differences which characterize these several groups are of the same nature, differing only in degree, in opposition to others who hold that they are based on different categories of structure, or on differences of *kind* rather than of degree. The falsity of the latter view is shown more and more clearly with the increase of our knowledge of the structure and affinities of animals.

While formerly species were considered as necessarily characterized either by differences of a particular kind, or by a certain amount of difference, the present tendency is to regard neither as a sufficient criterion, the test of specific diversity being merely absence of intergradation,—in other words, breaks in the continuity of closely allied beings. Local races, or geographical forms, are thrown together under one specific designation whenever they are found to intergrade, however diverse may be their extreme phases of differentiation. The term species is now made to cover groups which were, not many years since, frequently regarded as sub-genera, or even genera,—the forms then supposed, in numberless instances, to be "good species" now ranking merely as sub-species. The reduction in the number of species has necessarily entailed a considerable reduction in the number of currently accepted genera, which in turn are limited by hiati rather than by any given amount or particular kind of difference. It was formerly urged against the theory of evolution

that its advocates could point to no instance of the gradual change of one species into another, and that, until this was done, the theory was untenable. Among the species of North American vertebrates recognized as valid ten years ago, hundreds of instances can now be cited of thoroughly proven intergradation; forms then regarded as unquestionable species being found to be but connected phases of one and the same specific type, which assumes, at remote localities, under the evident action of climatic agencies, phases widely diverse, which gradually merge the one into the other through the individuals inhabiting the intervening districts. So long as species are based on the absence of intergradation,—and biologists have found no other satisfactory criterion for their limitation,—there can of course be no passage of one species into another. Let, however, some of the connecting links become extinct, and these now intergrading forms would be resolved into distinct species. In this way insular and other local forms are passing beyond the so-called varietal stage, and species are similarly tending to generic distinctness. That varieties may and do arise by the action of climatic influences, and pass on to become species, and that species become, in like manner, differentiated into genera, is abundantly indicated by the facts of geographical distribution and the obvious relation of local forms to the conditions of environment. The present more or less unstable condition of the circumstances surrounding organic beings, together with the known mutations of climate our planet has undergone in past geological ages, points clearly to the agency of physical conditions as one of the chief factors in the evolution of new forms of life. So long as the environing conditions remain stable, just so long will permanency of character be maintained; but let changes occur, however gradual or minute, and differentiation begins. If too sudden or too great, extinction of many forms must result, giving rise to breaks in the chain of genetically connected organisms. In the deep abysses of the sea, where the temperature is low and stable, where the conditions of life must have remained almost unvaried since the early geological periods, the same low organisms still exist that were the prevailing forms of life when life first dawned upon the earth. The recent explorations of the depths of the sea have

gone far to prove that stability of organic forms is in direct ratio to the stability of the conditions of existence, while the facts of geographical distribution show that change of structure and diversity of life are directly related to the physical conditions of habitat.

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